Research Proposal: NBER Post-Doctoral Fellowships in Innovation Policy

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Energy-intensive durable goods, such as passenger vehicles and large appliances, account for about half of U.S. greenhouse gas emissions. Adopting energy-efficient technologies and making technological progress can help mitigate climate change problems and help achieve a sustainable economy. Therefore, understanding the roles of innovation and technological changes are essential to designing and improving environmental policies and innovation policies.

Recent theories discuss how energy prices and R&D policies can spur the development of clean technologies measured by patents (Popp, 2002; Aghion et al., 2012; Acemoglu et al. 2014). However, we know little about how these policies affect energy-intensive durable goods in terms of their energy-efficiency levels and how these policies affect welfare. In addition, theories of endogenous technological change suggest several important mechanisms that may affect innovation such as the market size effect and the price effect (Acemoglu 2002). However, there is no empirical evidence on energy-intensive durable goods yet.

To address the knowledge gap, I am applying to the NBER Post-doctoral Fellowship in Innovation Policy to work on my research on energy-efficient innovations and policies. During the postdoctoral appointment, I propose to focus on the channels of energy-efficient technology improvements, the mechanisms that induce innovation and technological changes, and welfare consequences of these induced innovations.

My past research projects have bridged some of the knowledge gap described above. My job market paper, "*Knowledge Capital, Technology Adoption and Environmental Policies: Evidence from the US Automobile Industry*", examines how policy instruments incentivize firms to improve energy-efficient technologies using a structural model. I find gasoline taxes can be more effective in improving fuel efficiency via inducing technology adoption, whereas R&D subsidies can be more effective in helping firms become more productive and have lower cost of producing fuel-efficient cars. In "*The Effect of Market Size on Fuel-Saving Technology Adoptions in Passenger Vehicles*", joint with Thomas Klier and Joshua Linn, we argue the importance of *the market size mechanism* in the development of fuel-saving technologies. We find considerable market effect. And since a gasoline tax can affect the cross-sectional distribution of market size, it can polarize the fuel efficiency distribution.

My past research experiences have prepared me for future projects. Going forward, I plan to explore questions in my current research agenda in greater depth. In addition to my existing projects described above, there are two major projects that I propose to work on in the 2016-17 academic year of the postdoctoral appointment.

One project that I have started is "*International Environmental Benefit from Domestic Regulation: Assessing International Clean Technology Spillover*", joint with Antoine Dechezlepr être, Carolyn Fischer, Joshua Linn, and Elena Verdolini. Many firms targeted by environmental and innovation

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policies are multi-national firms. For multi-national firms that produce energy-intensive durable goods, policies they face in one jurisdiction can affects products they offer in the rest of the world.

In this study, we aim to empirically estimate how environmental and innovation policies in one jurisdiction can spillover to products they offer in other jurisdictions. For example, this study asks if Volkswagen produces more efficient cars in the US market, then to what extent it is caused by Volkswagen complying with a tighter fuel economy standard in EU or by Volkswagen being induced by R&D policies in EU. To achieve, we assemble a unique data linking vehicles characteristics and vehicle sales information across multiple regions including US, EU and India in 2002-2013. To support this study, I plan to submit the NSF Science of Science and Innovation Policy Early-concept Grants for Exploratory Research (SciSIP-EAGER) Grant in September 2016. I plan to use this grant to extend US, EU and India data to cover more recent years after 2013 as well as to cover data in other important markets such as Japan, China and Mexico.

Here I describe the second major project that I propose to work on. To complement my work on the market size effect, a natural follow-up is to investigate other important mechanisms suggested in the technological change theories. Acemoglu (2002) suggest that *the price effect* is an important driver of the direction and the rate of innovation and technological change. However, there is no empirical evidence on energy-intensive durable goods yet.

To bridge this gap, I plan to explore the price effect of intermediate goods on energy-intensive durable final goods. Specifically, I plan to examine the roles of the automotive original equipment manufacturers (OEM) in my analysis, also known as upstream suppliers. Suppliers are important players and important innovators in the automobile industry. Their choices on prices and engine specifications as well as their market power can affect the effectiveness of government policies. However, their roles in innovation policies are rarely studied in empirical works. I am interested in exploring the roles of their pricing mechanisms, their bargaining power and their choices on engine production in shaping the path towards greener technologies and a greener future.

To achieve, I plan to obtain transaction information and contract information on vehicle engines and other automotive parts between upstream automotive suppliers and downstream automotive manufacturers. I plan to link this information to vehicle characteristics and sales data, and estimate important parameters and cost components using a structural framework. I also plan to collect knowledge capital of automotive suppliers using patent data. This project will benefit from resources in NBER, especially the NBER USPTO Patent Project Database as well as the NBER NBER-Rensselaer Polytechnic Institute Scientific Papers Database. To support this study especially to obtain data of automotive OEMs, I plan to apply for the 2016 E2e Energy Efficiency Research Design Grant (supported by the E2e Project and the Alfred P. Sloan Foundation) in December 2015 prior to the postdoctoral appointment.

Here I propose my research schedule. Within the first 3 months of the post-doc appointment, I anticipate to submit my job market paper as well as my project on market size effect to peer-reviewed journals. I also plan to submit the NSF SciSIP Grant application in September to support my project on international innovation spillover. During the 4^{th}-6^{th} month of the appointment, I plan to focus on the international innovation spillover project and have a complete paper ready for circulation. At the same time, I plan to start on my OEM innovation project on data as well as empirical strategies. During 7th-12th month, I plan to focus on the OEM innovation project and to

produce initial results. During the last 3 months, I plan to complete and submit my work on the international innovation spillover to a peer-reviewed journal.

My research will benefit from NBER data resources and interactions with the Productivity, Innovation, and Entrepreneurship (PIE) program and the Innovation Policy (IPE) working group. I expect my research to serve the missions and research thematic of PIE program and IPE working group by providing knowledge on energy-efficient technologies and on policies to induce green innovations.

Reference

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